

# CORRESPONDENCE BETWEEN SPINAL CORD SEGMENTS AND VERTEBRAE IN GOAT FOETUSES\*

S. Maya<sup>1</sup>, J. J. Chungath<sup>2</sup>, K. R. Harshan<sup>3</sup>,  
N. Ashok<sup>2</sup> and K. S. Sujatha<sup>4</sup>

Department of Veterinary Anatomy and Histology  
College of Veterinary and Animal Sciences  
Mannuthy -680 651, Thrissur, Kerala

## Abstract

*Correspondence between spinal cord segments and vertebrae in foetal goats was studied using 52 fetuses ranging from 1.4 cm CRL (24 days of gestation) to 41.5 cm (full term). In the present study, upto the latter half of second month of gestation, the spinal cord extended the entire length of vertebral canal. Towards the end of the second month, the cranial ascend was initiated. In the third and fourth month, the lumbar region reached only upto the middle of L6 vertebra. During the fifth month, lumbar region reached upto the caudal end of L5 vertebra. A corresponding cranial ascend was noticed in the sacral and coccygeal regions. The spinal cord termination was at fourth coccygeal vertebra upto 54 days of gestation. Towards the end, it was at third coccygeal vertebra. By third month, the level was between first and second coccygeal vertebrae. By fourth month, it varied from first coccygeal to fourth sacral vertebrae. During fifth month, the level of termination varied from rostral end of S4 through middle of S3 to caudal end of S2. This rostral ascend was due to the faster rate of the growth of the vertebral column than the spinal cord during prenatal period.*

**Key words :** Correspondence, foetus, goat, prenatal, spinal cord, vertebra

The fact that the spinal cord is not co-extensive with the entire vertebral canal, and spinal cord segments do not lie within the boundaries of their corresponding vertebrae, seems to be a recognizable feature for many mammals. In domestic animals, the vertebral column overgrows the cord, so that beyond the most cranial cervical region, the cord segments lay cranial to their corresponding vertebrae. The nerve roots make progressively more acute caudal angles to the cord as they proceed to their appropriate exits with the resultant formation of filum terminale and cauda equina. The caudal extremity of the spinal cord tapers as the conus medullaris and the level of termination varies among species (and in early stage with age). The correspondence between cord segments and vertebrae and the level of termination of the cord in different species of domestic animals has been studied by several workers (Kreig and Groat, 1944; Fletcher and Kitchell, 1966; Sharma and Rao, 1971). But as a detailed study on these aspects in goat fetuses has been very limited, this work was undertaken to elucidate the same at various stages of prenatal life in this species.

## Materials and Methods

The study was conducted on 52 goat fetuses ranging from 1.4 cm CRL (Crown

\* Part of Ph.D. thesis submitted by the first author to the Kerala Agricultural University, Thrissur

1. Associate Professor & Head, Dept. of Veterinary Anatomy, COVAS, Pookot, Wayanad

2. Professor

3. Professor & Head

4. Associate Professor & Head, Dept. of Statistics

rump length) (24 days of gestation) to 41.5 cm (full term). Immediately after collection, the body weight of the fetuses was recorded. The age was calculated using the formula derived by Singh *et al.* (1979), for goat fetuses,  $W^{1/3} = 0.096 (t - 30)$ , where,  $W$  = body weight in g, and  $t$  = age in days.

Based on the age, the fetuses were divided into five groups corresponding to five months of gestation. Since the spinal cord and vertebral column started to attain their morphological characters only by the second month, their parameters were measurable only from second month onwards. The material was fixed in 10 per cent neutral buffered formalin. The spinal cord was exposed by cutting the dorsal side of the vertebrae by laminectomy, the lateral sides by paramedian section and by clipping off the pedicles so as to remove the walls of the vertebral canal. Intervertebral discs and their relationship to the cord segments were recorded. Gross features such as length of filum terminale (from the conus medullaris upto its termination) and the level of termination of spinal cord (with reference to rostral, middle or caudal third of the body of a particular vertebra) were recorded.

## Results and Discussion

The foetal goat had 36 segments for the spinal cord depending upon the origin of spinal nerves *viz.* eight cervical(C), 13 thoracic(T), six lumbar(L), four sacral (S) and five coccygeal(Cy). Among the 52 fetuses under study, eight animals showed more than 36 segments because of the increased number of coccygeal nerves upto seven or eight pairs. The vertebral column consisted of seven cervical, 13 thoracic, six lumbar, four sacral and 12 to 15 coccygeal vertebrae.

Towards the termination of the second month, the spinal cord extended along the entire length of the vertebral canal with the conus medullaris at fourth coccygeal vertebra. So, the regions of the spinal cord corresponded to the respective regions of the vertebral column (Fig.). According to Sadler (2004) in man, the spinal cord extended the entire length of vertebral canal upto the third month of gestation.

By 57 days of gestation, the level of termination was at the anterior end of third coccygeal vertebra. From the tapering caudal

extremity of conus medullaris, a very short filum terminale extended caudally.

The mean length of the filum was  $1.333 \pm 1.033$ ,  $2.092 \pm 0.424$ ,  $11.000 \pm 1.155$  and  $40.250 \pm 3.988$  mm during second, third, fourth and fifth month of gestation, respectively. According to Bowsher (1967), the filum terminale was a strand of primitive neuroectoderm by which, the lower end of the spinal cord in man was tethered to the back of the coccyx.

In the third month, a slight ascend of the spinal cord was noticed as the lumbar region extended upto the middle of L6 vertebra. So a corresponding ascend was noticed in the sacral and coccygeal regions with the level of conus varying between first and second coccygeal vertebrae. So from third month onwards, all the cord segments did not correspond to the transverse and vertical planes of the corresponding vertebrae. This substantiates the observations in cat (Kreig and Groat, 1944), dog (Fletcher and Kitchell, 1966) and buffalo (Sharma and Rao, 1971).

During the fourth month, the lumbar region of the spinal cord reached upto the same level as that in the third month of gestation, *ie.* the middle of L6 vertebra, but the sacral region extended only upto the middle of S3. By the beginning of the fourth month, the level of conus was at the first coccygeal vertebra, but towards the second half of fourth month, it was at the fourth sacral vertebra.

In the fifth month, the lumbar region extended only upto the caudal end of L5 vertebra, with the sacral region extending upto the middle of S1. The level of conus varied from cranial end of fourth sacral vertebra at the beginning, through middle of third sacral to caudal end of second sacral vertebra by the end of gestation (Fig.). These findings partially agree with those of Taluja and Shrivastava (1984) in foetal goat. According to them the level of termination of spinal cord varied from caudal end of S4 to rostral end of Cy1 vertebra in the first trimester, caudal end of S3 to rostral end of S4 in second trimester and caudal end of S2 to rostral end of S3 in third trimester of gestation.

As per earlier reports, the level of termination in adult goat is at S3 (Sharma *et al.*, 1973) or S2 levels (Dellmann and McClure, 1975; Chandna and Tyagi, 1981). In the present study, the level of termination of spinal cord in goat fetuses almost came close to



that reported in adult goat, confirming the reports of Sharma and Rao (1971). A knowledge about the level of termination is important during the administration of epidural anaesthesia to avoid injury to the spinal cord.

In all age groups, C1 to C7 spinal cord segments were lying within the corresponding vertebrae. Due to the presence of the C8 spinal cord segment, the rest of the spinal cord segments in the cranial and middle thoracic regions, *ie.* upto T6 or T10 segments, were lying within the next vertebra. As the middle thoracic segments ascended cranially due to their shorter length compared with the caudal thoracic segments, the caudal thoracic and cranial lumbar segments, *ie.* from T8 or T10 and cranial lumbar segments upto L3 or L4 came to lie within their corresponding vertebrae again. This feature was seen more pronounced in the second half of gestation in the present study. This finding was in accordance with the observation of Hopkins (1935) in domestic animals.

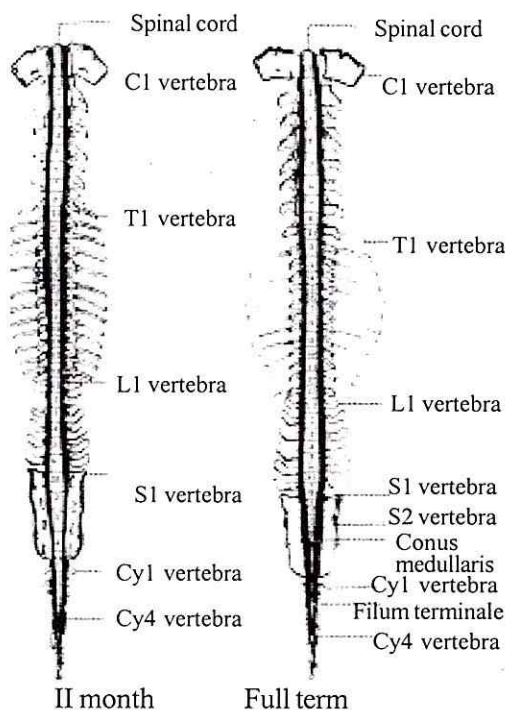
The mean total length of vertebral column was  $62.750 \pm 4.267$ ,  $108.833 \pm 7.581$ ,  $188.200 \pm 2.435$  and  $349.643 \pm 19.067$  mm during second, third, fourth and fifth month of gestation, respectively. Regression analysis showed that the rate of growth of vertebral column length in relation to the age was  $3.556 \pm 0.401$ ,  $2.752 \pm 0.132$ ,  $1.747 \pm 0.449$  and  $6.860 \pm 0.419$  mm during second, third, fourth and fifth month of gestation, respectively. The maximum rate was during the fifth month.

The vertebral canal extended from the first cervical to fourth coccygeal vertebra. The vertebral canal length increased progressively 5.786 times from  $58.833 \pm 2.358$  mm in the second month, through  $92.925 \pm 6.496$  in third month,  $161.800 \pm 1.925$  in the fourth month to  $304.429 \pm 16.023$  mm in the fifth month of gestation. For unit change in age, the change in vertebral canal length was  $3.444 \pm 0.351$ ,  $2.365 \pm 0.097$ ,  $1.453 \pm 0.317$  and  $5.680 \pm 0.454$  mm during second, third, fourth and fifth month respectively, with the maximum growth rate recorded at the fifth month.

The mean length of the spinal cord was  $52.625 \pm 3.495$ ,  $90.917 \pm 6.290$ ,  $150.800 \pm 2.164$  and  $264.179 \pm 12.308$  mm during second, third, fourth and fifth month, respectively. The growth rate of spinal cord length showed a decreasing trend upto the fourth month, but during the fifth month it exhibited the maximum rate of  $4.408 \pm 0.297$

mm. During second, third and fourth month, the growth rates were  $2.852 \pm 0.262$ ,  $2.279 \pm 0.119$  and  $1.278 \pm 0.506$  mm, respectively.

**Fig.** Correspondence between spinal cord segments and vertebrae



Comparative length of spinal cord, vertebral column and vertebral canal are shown in the figure. All the parameters exhibited the maximum rate of increase during the fifth month. At all stages of growth, the rate of growth of vertebral column and vertebral canal exceeded that of the spinal cord in the present study. This is in accordance with the reports of Barry (1956) in man, who stated that even though in the early embryonic life the spinal cord extended upto the end of the vertebral canal, in subsequent prenatal and postnatal development, the growth of vertebral column was faster than that of the spinal cord. This produced a relative shortening of the latter and an apparent cranial displacement of its segments. During this differentiation process, the spinal cord played a relatively passive role and the vertebral column simply overgrew the cord.

### Acknowledgements

We express our sincere gratitude to the Dean, College of Veterinary and Animal Sciences, Mannuthy, Kerala and the

authorities of Kerala Agricultural University, for providing the facilities to do this research work.

## References

- Barry, A. 1956. A quantitative study of the prenatal changes in angulation of the spinal nerves. *Anat. Rec.*, **126**: 97-110
- Bowsher, D. 1967. *Introduction to the Anatomy and Physiology of the Nervous System*. Blackwell Scientific Publications, Oxford, 180 p.
- Chandna, I.S. and Tyagi, R.P.S. 1981. Radiographic and topographic anatomy of the vertebral column and the spinal cord of caprines. *Indian Vet. J.*, **58**: 649-651
- Dellmann, H.D. and Mc Clure, R.C. 1975. Central nervous system. *Sisson and Grossman's The Anatomy of the Domestic Animals, Volume I*. 5<sup>th</sup> ed., (Ed. Getty, R.). W.B. Saunder's Company, Philadelphia, pp. 1065-1080
- Fletcher, T.F. and Kitchell, R.L. 1966. Anatomical studies on the spinal cord segments of the dog. *Am. J. Vet. Res.*, **27**: 1759-1767
- Hopkins, G.S. 1935. The correlation of anatomy and epidural anaesthesia in domestic animals. *Cornell Vet.*, **25**: 263.
- Kreig, W.I.E. and Groat, R.A. 1944. Topography of the spinal cord and vertebral column of the cat. *Q. Bull. Nw. Univ. Med.*, **18**: 265
- Sadler, T.W. 2004. *Langman's Medical Embryology*. 9<sup>th</sup> ed., Lippincott Williams and Wilkins, Philadelphia, 534 p.
- Sharma, D.N. and Rao, G.S. 1971. Topography of spinal cord segments in buffalo (*Bubalis bubalis*). *Indian J. Anim. Sci.*, **41**: 161-165
- Sharma, D.N., Singh, Y. and Dhingra, L.D. 1973. Anatomical studies on the spinal cord segments of goat (*Capra hircus*). *Haryana agri. Univ. J. Res.*, **3** : 87-92
- Singh, Y., Sharma, D.N. and Dhingra, L.D. 1979. Morphogenesis of testis in goat. *Indian J. Anim. Sci.*, **49**: 925-931
- Taluja, J.S. and Shrivastava, A.M. 1984. A note on the vertebral level of termination of the spinal cord in goat fetuses. *Indian Vet. J.*, **61**: 1087-1088

